动 物 学 研 究 1994, 15 (增刊): 74—81 CN 53-1040/Q ISSN 0254-5853
Zoological Research

DEVELOPMENT OF THE PHARYNGEAL TEETH IN THE CHINESE LABEONINE FISH *Cirrhinus molitorella*

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Abstract Adult pharyngeal teeth in *Cirrhinus molitorella* are compressed in anterior and posterior direction and formed secondary grinding surface with wear. Based on the observations of the teeth by SEM, the morphological diversification of the teeth in *C. molitorella* were described in this paper. The larval and juvenile teeth are changed from conical to adult teeth through seven stages. And comparisons are made between developments of the teeth in *C. molitorella* and *Mylopharyngodon piceus*, of which the development of the teeth is described in the previous paper (Nakajima *et al.*).

Key words *Cirrhinus molitorella*, Pharyngeal teeth, Morphological diversification, Developmental process

1 Introduction

Cyprinid fishes bear well-developed pharyngeal dentition on the fifth pharyngeal arch. External features, numbers and arrangements of the teeth have often been studied as a criteria for taxonomic classification. Adult cyprinids bear various pharyngeal dentitions, however, the teeth in their larvae are similar to each other in shape and arrangements (Nakajima, 1979, 1984). The initial teeth in Cypriniforms are recurved and conical and changed into different forms by replacements (Vasnecov, 1939; Weisel, 1967; Nakajima, 1979, 1984, 1987, 1990; Kodera, 1982; Nakajima *et al.*, 1989). Vasnecov (1939) used the changes in tooth form as evidence for the direction of phylogeny in Cypriniforms. Since then, other authors have suggested the possibility that the morphological change of pharyngeal teeth during successive replacements indicates the phylogeny of Cypriniform fishes (Weisel, 1967; Kodera, 1982; Nakajima,

本文 1994 年 9 月 5 日收到

1990; Nakajima *et al.*, 1989). Nakajima *et al.* (MS) described the morphological diversification of teeth in *Mylopharyngodon piceus*, and discriminate the developmental change of teeth in *M. piceus* into eight stages.

Cirrhinus molitorella belongs to the subfamily Labeoninae of the family Cyprinidae. Generally, the pharyngeal teeth of labeonine adults are compressed in anterior and posterior direction and formed secondary grinding surface with wear. The present study is undertaken to clarify the development of dentition in *Cirrhinus molitorella* and to compare it with that in *M. piceus*.

2 Materials and Methods

Larvae and juveniles of *Cirrhinus molitorella* were reared from eggs artificially fertilized in the laboratory, and sampled at random. Parent fish of them were captured in Xingning, Guangtong Province, China. Specimens of *Cirrhinus molitorella* were examined.

Specimens were fixed in 10% formalin, and cleared in 1% KOH, stained with alizarin red S, and stored in 80% ethyl alcohol. In every specimen, the pharyngeal arches with their mucous membrane were removed from the head, submerged in pure glycerine, and examined under binocular microscope. Some stained pharyngeal arches were re-fixed in 2% osmic acid. The soft tissue with unattached tooth germs was removed from them, leaving attached teeth in place. The bone and ankylosed teeth were dried with a critical-point drier, coated with gold by an ion spatter, and examined in a scanning electron microscope. The figures were based on scanning electron micrographs.

3 Results

The shape of teeth in adult fish. The dental formula in this species is 2.4.5-5.4.2. The secondary grinding surface is formed with wear. The secondary grinding surface falls at right angle with tooth axis. Each tooth is compressed in anterior and posterior direction(Fig. 1-F).

The morphology of teeth changes with developmental process. In the present species, the dentition was complex, so each tooth was not able to be identified. Therefore, the teeth are represent with tooth positions of the adult dentition. There are five teeth in the major row of the adult dentition, so positions A1, A2, A3, A4 and A5 in the adult dentition are corresponded to positions An3, An2, An1, Ce0 and Po1 in the larval dentition, respectively. The tooth positions in the larval dentition are shown in parenthesizes for information.

A larva, 8.8 mm in standard length (SL), bears the larval dentition (Fig. 1-A). Six teeth are ankylosed to the bone. There are two teeth at position A3(An1). The medial tooth are replacement tooth of the lateral tooth at position A3(An1). The tooth at position A1(An3) is conical. The lateral tooth at position A3(An1) bears small grind-

ing surface which faces posteriorly. The medial four teeth at positions A2(An2), A3(An1), A4(CeO) and A5(Pol) bears narrow grinding surface which face posteriorly also. The tooth at position A5(Pol) is bent anteriorly at tooth neck, but this condition seems to be artificial.

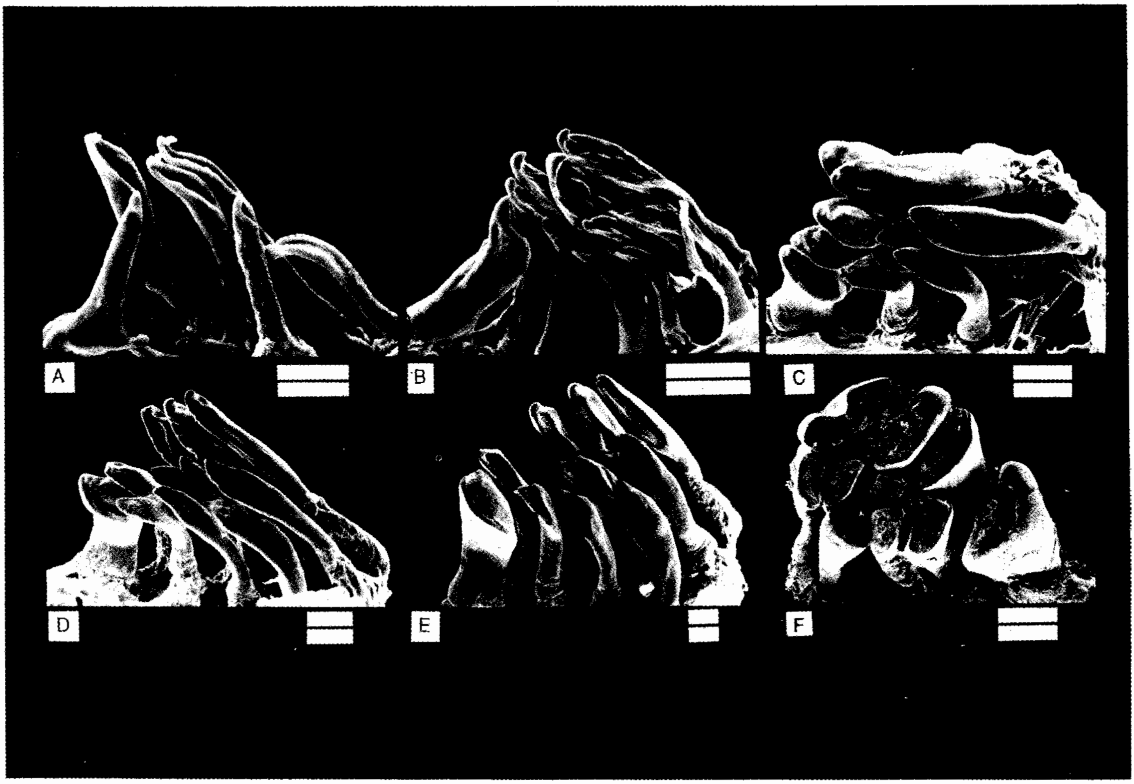


Figure 1 Scanning electron microphotographs of the pharyngeal dentitions of the larva to adult in *Cirrhinus molitorella*

A: lateral view of the larval dentition at 8.8 mm SL. B: lateral view of the adult dentition at 10.0 mm SL. C: lateral-occulusal view of the adult dentition at 15.0 mm SL. D: lateral view of the adult dentition at 19.7 mm SL. E: lateral view of the adult dentiton at 27. 4 mm SL. F: Occulusal view of the adult dentition at 170.0 mm SL.

Scale bars: A: 500 μm; B, C, D, E: 100 μm; F: 1 mm.

A larva, 10.0 mm SL, bears the adult dentition (Fig. 1-B). Ten teeth are ankylosed to the bone. Tooth B2 is missing. All the tooth bears a hook at the tip. The teeth in the major row and tooth B4 bear broad grinding surface with many small denticles. The grinding surface of teeth A1, A2 and A3 faces posteriorly. Teeth B1, B3, C1 and C2 bear a narrow grinding surface which faces posteriorly also. The tooth neck of teeth A3, A4 and B4 is slightly twisted. That of the tooth A4 is strongly twisted, so the lateral margin of the grinding surface becomes orientated anteriorly and the

medial margin posteriorly. The anterior margin of the grinding surface of tooth A4 becomes sharp and makes a curve. The hollow on the grinding surface becomes a groove along the anterior margin on tooth A4.

A juvenile, 15.0 mm SL, bears the adult dentition (Fig. 1-C). Ten teeth are ankylosed to the bone, and tooth C2 is missing. All the tooth bears a broad and smooth grinding surface with a hook at the tip. The tooth neck is twisted and the grinding surface faces laterad except for teeth B1 and C1. The lateral margin of the grinding surface is orientated anteriorly and the medial margin posteriorly. The anterior margin of the grinding surface becomes sharp and makes a curve. The posterior margin becomes blunt. The hollow on the grinding surface becomes a groove along the anterior margin.

A juvenile, 19.7 mm SL, bears the adult dentition (Fig. 1-D). Eleven teeth are ankylosed to the bone. All the tooth is compressed in anterior and posterior direction except for tooth A1. The anterior margin of the grinding surface is sharp and makes a curve. The posterior margin of the grinding surface is blunt. The grinding surface is smooth. The groove runs along the anterior margin on the grinding surface.

A juvenile 27.4 mm SL, bears the adult dentition(Fig. 1-E). Eleven teeth are ankylosed to the bone. Teeth are worn. And the dentin layer is exposed in some teeth. The secondary grinding surface begin to be formed. The compression of teeth becomes remarkable.

4 Discussion

The larval and juvenile teeth are changed morphologically to adult teeth through seven stages as follows.

Stage 1 (Fig. 2-A): Teeth are recurved and conical. This stage is corresponding to stage 1 in *M. piceus*.

Stage 2(Fig. 2-B): Teeth bear a narrow grinding surface and a hook at the tip. The grinding surface faces posteriorly. This stage is corresponding to stage 2 in *M. piceus*.

Stage 3(Fig. 2-C): Tooth neck is slightly twisted. The grinding surface faces slightly laterad. Denticles are distributed on the grinding surface. This stage is corresponding to stages 3 and 4 in *M. piceus*.

Stage 4 (Fig. 2-D): Tooth neck is more twisted, and the grinding surface faces laterad. The lateral margin of the grinding surface becomes orientated anteriorly, and the medial margin posterior. The anterior margin makes a curve. The posterior margin becomes blunt. The grinding surface becomes broad and forms shallow hollow like a groove, and many denticles are distributed on it. This stage is corresponding to stage 5 in *M. piceus*.

Stage 5(Fig. 2-E): Teeth are not changed from the teeth at the fourth stage in outline of shape. Denticles on the grinding surface are disappeared, and the grinding sur-

face becomes smooth. The hollow on the grinding surface becomes a groove along the anterior margin. This stage is corresponding to stage 6 in *M. piceus*.

Stage 6(Fig. 2-F): Teeth are compressed in anterior and posterior direction. The anterior margin of the grinding surface is sharp and make a curve. The posterior margin is more blunt and disappeared. This stage is not corresponding to all the stage in *M. piceus*.

Stage 7 (Fig. 2-G): Teeth are worn, and the dentine layer is exposed. The secondary grinding surface is formed. This stage is not corresponding to all the stage in *M. piceus*.

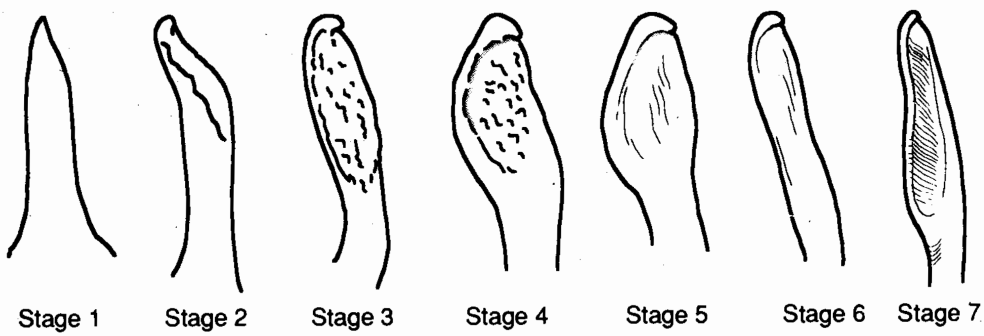


Figure 2 Developmental stages of the pharyngeal teeth in *Cirrhinus molitorella*

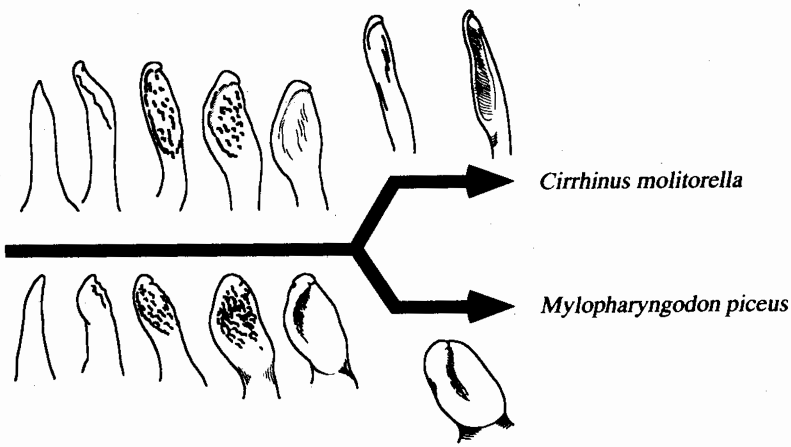


Figure 3 Comparison between developmental process of *Cirrhinus molitorella* and *Mylopharyngon piceus*

Data of *M. piceus* are cited from Nakajima and Yue (MS)

Nakajima and Yue (MS) studied the morphological diversification of the pharyngeal teeth in *Mylopharyngodon piceus*. The developmental change of the teeth in *Cirrhinus*

molitorella is corresponded to that in *M. piceus* in late stages, from stage 1 to stage 5 (Figs. 3 and 4). Teeth in *C. molitorella* become labeonine teeth characterized by compression in anterior and posterior direction at the stage 6.

Teeth of danionines (*Zacco* and *Barilius*), barbines (*Barbus* and *Puntius*), hypophthalmichthyines and leuciscines (*Tribolodon*) are diverged from the developmental process of teeth in *Mylopharyngodon piceus* at early stages (Nakajima and Yue, MS). On the other hand, the teeth of *Cirrhinus* share common developmental process with *Mylopharyngodon*, *Gnathopogon*, *Hemibarbus* and *Cyprinus* until stage 5(Fig. 4). These data lead us to the conclusion that labeonines are more similar to cyprinines and gobionines in pharyngeal teeth development than to danionines, leuciscines and barbinines.

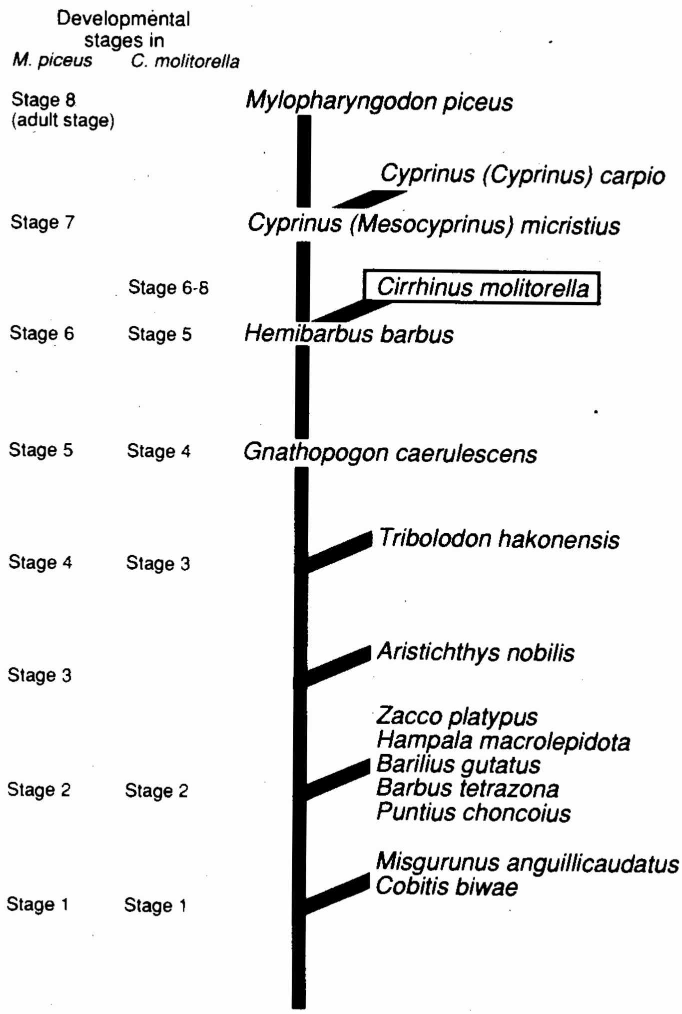


Figure 4 Comparison between developmental process of various cyprinids

Data of *Cirrhinus molitorella* are added in the figure of Nakajima and Yue (MS)

References

Kodera H, 1982. Morphodifferentiation of the pharyngeal teeth of the carp, *Cyprinus carpio* Linne. *Tsurumi Univ. Dent. J.*, **8**: 179-212.

Nakajima T, 1979. The development of the pharyngeal dentition in a Japanese cyptinid fish, *Gnathopogon coerulescens*. *Copeia*, **1979**: 22-28.

Nakajima T, 1984. Larval vs. adult dentiton pharyngeal dentition in some Japanese cyprinid fishes. *J. Dent. Res.*, **63**: 1140-1146.

Nakajima T, 1987. Development of the pharyngeal dentiton in the cobitid fishes, *Misgurnus anguillicaudatus* and *Cobitis biwae*, with a consideration of evolution of Cypriniform dentitions. *Copeia*, **1987**: 208-213.

Nakajima T, Yue P Q, 1989. Development of the pharyngeal teeth in the big head, *Aristichthys nobilis* (Cyprinidae). *Japan. J. Ichthyol*, **36**: 42-47.

Nakajima T, 1990. Morphogenesis of the pharyngeal teeth in the Japanese dace, *Tribolodon hakonenesis* (Pisces: Cyprinidae). *J. Morphol*, **205**: 155-163.

Nakajima T, Yue P Q, 1994. (MS) Morphological changes in development of pharyngeal teeth in *Mylopharyngodon piceus*.

Vasnecov V V, 1939. Evolution of the pharyngeal teeth in Cyprinidae. *A la memoire de A. N. Severtzoff*, **1**: 439-491.

Weisel G F, 1967. The pharyngeal teeth of larval and juvenile suckers (*Catostomus*). *Copeia*, 50-54.

中国野鲮亚科鱼类——鲮鱼咽齿发育的研究

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摘要　鲤科鱼类第 5 对咽弓上着生有发育良好的咽齿。不同种类鱼类咽齿的外形、数目和排列上的差异，常被认作分类依据并在鱼类系统学上具重要意义。

无论鲤科鱼类成体的咽齿具多大差别，而在生长的最初阶段，几乎所有种类咽齿的形状和排列都相同（中岛，1979，1984），且经众多学者深入研究，结果一致。初期咽齿呈锥形，略后弯，通过生长过程的系列置换，向着各自固有的齿形转化，最后形成多样性的咽齿齿型。

瓦兹涅错夫（1939）将咽齿发育中齿形的转换作为鲤形目鱼类系统发育导向的佐证。嗣后，其他学者也均支持咽齿连续置换中形态变化所呈现的系列差异作为鲤形目鱼类系统发育演化过程中的暗示。

系统分类上，鲮鱼属于鲤科的野鲮亚科，齿式 2.4.5—5.4.2，成体齿形呈前后向侧扁，并形成长形的次级咬合面。由仔鱼向成鱼型发育过渡的转换需经历 7 个阶段。

1. 齿呈锥形，后弯，与青鱼咽齿发育比较，相当于其第 1 阶段。

2. 齿具狭窄的咬合面，齿面向后，顶端尖钩，与青鱼咽齿发育的第 2 阶段相当。

3. 齿颈稍扭，咬合面稍增宽，上具小突起，相当于青鱼的第 3、第 4 阶段。

4. 齿颈扭曲，咬合面宽，呈浅凹，面上布有多数小突，与青鱼咽齿第 5 发育阶段相当。

5. 齿面外形不变，咬合面凹陷沿前缘形成一沟，小突消失，与青鱼发育中第 6 阶段对应。

6. 齿前后向侧扁，咬合面由宽圆向长形发展，前尖后钝，而后其后缘逐渐消失。

7. 在前阶段不变齿形的基础上，形成次级咬合面。

鲮鱼咽齿发育的最后两阶段是向其特有性状发展，在青鱼咽齿发育阶段中无法找到对应期。

鲤科内鲌类中的鳊和低线鱲；鲃类中的鲃和无须鲃；鲢类；雅罗鱼类中的三块鱼等鱼类的咽齿，均经由青鱼咽齿的较早期发育阶段而发展分离的。鲮鱼咽齿的一般发育过程在第 5 阶段之前，显现出颌须鮈、鲴、鲤及青鱼等相应的发育阶段的形态。上述资料表明，野鲮类与鮈类、鲤类的咽齿发育表现出较多的相似性，而与鲌类、雅罗鱼类和鲃类的咽齿发育则有明显区别。

关键词　鲮鱼，咽齿，形态变化，发育过程